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Inhomogeneous and Nonstationary Feature Analysis: Melding of Oceanic Variability and Structure (INFAMOVS)
Principal Investigator: Arthur J. Mariano
Grant No: N00014-91-J-1120

The primary research goals were (i) the development of new data analysis and assimilation techniques; (ii) application of these techniques, production of optimal estimates of oceanic fields and frontal locations for studying oceanic variability; iii) assimilation of satellite and in situ data sets into layered shallow-water models, such as the Miami Isopycnal Coordinate Ocean Model (MICOM) and the Navy's layered ocean model.

The following techniques were developed: (1) Contour Analysis (e.g. Mariano and Chin, 1995), (2) Parameter Matrix Algorithm for Objective Analysis (OA) (Mariano and Brown, 1992), (3) Empirical Orthogonal Contours (EOC) (Mariano, 1996; Mariano and Chin, 1996). (4) Motion-compensated space-time interpolation algorithms (Chin and Mariano, 1995) (5) Nearly-optimal wavelet and Markov Random Field approximations to the Kalman filter/smoother (e.g. Chin et al., 1995; Chin and Mariano, 1995).

These techniques were applied to the following data sets, that are available via anonymous ftp from playin.rsmas.miami:

1) The analysis of bio-physical variability during the BIOSYNOP/ Anatomy of a Meander experiment.

2) The analysis of oceanic frontal variability, e.g. Gulf Stream and Kuroshio paths, for determining the dominant patterns of spatial and temporal variability.

3) Global satellite-derived Sea Surface Temperature (SST)

4) Ship-drift based sea surface velocity estimates.

5) Hurricane Gilbert ocean response experiment.

Some of the major results of our studies are:

The parameter matrix algorithm can be used for efficient objective analysis of large satellite data sets and can be used for mapping fields in strong frontal regions. The use of contour positions for analyzing oceanographic data is a powerful approach. The use of a time-dependent bi-cubic spline surface can be used to represent the large-scale flow field and can be used for the estimation of diffusivity from (quasi-) Lagrangian data (with A. Griffa, S. Bauer, M. Swenson, USC mathematicians).

Wavelet-based, Gaussian-Markov Random Field (GMRF) and square-root filtering approximations to the Kalman smoother are efficient and lead to accurate estimates. Numerical properties of the Kalman filter-based space-time interpolator has been extensively studied (op. cit.). A wavelet-based approximation to the covariance function for efficient Kalman smoothing has been applied to a series of one-dimensional problems with very encouraging results-only a 1-5% degradation from a full-blown Kalman filter. An GMRF-approximated implementation of the Kalman filter was applied to a two-gyre one layer version of the MICOM model for the assimilation of sea surface height data. Assimilation of boundary data over a triangular portion of the rectangular analysis domain was also successful (Chin and

Mariano, 1995). This latter test is important for developing efficient assimilation techniques for irregularly-shaped domains on massively parallel computers.

In the upper water column of a Gulf Stream meander crest, density variability is more tightly coupled to temperature variability than salinity variability. In summary, 50 to 80% of the variance of density, salinity, chlorophyll a and temperature is explained by a cross-stream trend. Meander-induced convergences (divergences) and ring-stream interaction explains about 15 to 30% of the variability in these fields. On the other hand, 20% and 50% of zooplankton variability can be explained by a cross-stream trend and diurnal migration, respectively. This detailed quantitative study of the relationship between phytoplankton, zooplankton, and their environment for a Gulf Stream meander crest that will serve as a benchmark for bio-physical modeling efforts

The first Gulf Stream frontal EOC is fairly coherent south-to-north shifts of the stream east of 70 west. The second mode is an out of phase oscillation centered about the seamount region. Gulf Stream path variability is very broad-banded. There is a clear annual signal with the path further south in the spring and further north in the fall, on the average. However, there is a great deal of interannual variability in this annual signal. Besides an energetic mesoscale signal, there are indications of significant variability for periods greater than one year. A smaller subset of Kuroshio paths, from 1990 to 1993, were analyzed in the region, 130 to 170 east. The dominant temporal variability were at periods greater than one year with a relatively small contribution at the annual period.

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Dear Sir/Madam:

Enclosed herewith please find three (3) copies of the final report on the completion of Grant No. N00014-91-J-1120 *INFAMOVS*.

We are grateful to the Office of Naval Research for providing us with funds to carry out this research.

Yours sincerely,

Arthur Mariano

A. J. Mariano
Assistant Professor

AJM/em

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